



WELCOME

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Analysis and Design Of Multistoreyed Apartment Using Tekla

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INTRODUCTION



- Planning, analyzing and manual designing of main structures of 16 storeyed residential apartment.
- Chakkaraparambu, near bypass, Kochin, Ernakulam district
- Total area:9864 meter sq.
- Close proximity to CIAL, sea port-air port road, other reputed schools and colleges
- Modeling in BIM software TEKLA STRUCTURAL DESIGNER 2016

Literature review



International Research Journal of Engineering and Technology
(IRJET)

“Analysis and design of multistory building by using softwares”

L.G.Kalurkar:

- The design and analysis of multistoried G+12 building at earthquake zone-3.
- modeling and analysis of the structure are carried out in SAP 2000
- Equivalent Static Method of Analysis And Response spectrum analysis method
for the analysis of both Composite and RCC structures.
- The results are compared and found that composite structure more economical.

Literature Review



Analysis and Design of G+5 Residential Building.*“IOSR journal of mechanical and civil engineering (IOSR-JMCE)”*,

1. DESIGNING OF SLABS:-

Roof slab and floor slab are designed

Roof slabs are designed as one way slab

i.e., dead Loads due to water proofing= 2.5KN/m^2 ,

self weight of the slab= $1 \times 1 \times \text{required depth} \times 25$)

live loads (roof= 1.5KN/m^2)

Literature Review



- **DESIGN OF BEAM:-**
- A reinforced concrete beam should be able to resist tensile compressive
- and shear stresses induced in it by the loads on the beam.
Concrete is fairly strong in compression but very weak in the low tensile strength.
- Plain concrete beams are thus limited in carrying capacity by the low tensile strength.
- Steel is very strong in tension.
- Thus the weakness of concrete is overcome by the provision of reinforcing steel in the tension zone around the concrete to make a reinforced concrete beam

Literature Review



- **”Study of seismic analysis and design of multi storey symmetrical and asymmetrical building”, International Research Journal of Engineering and Technology (IRJET)**

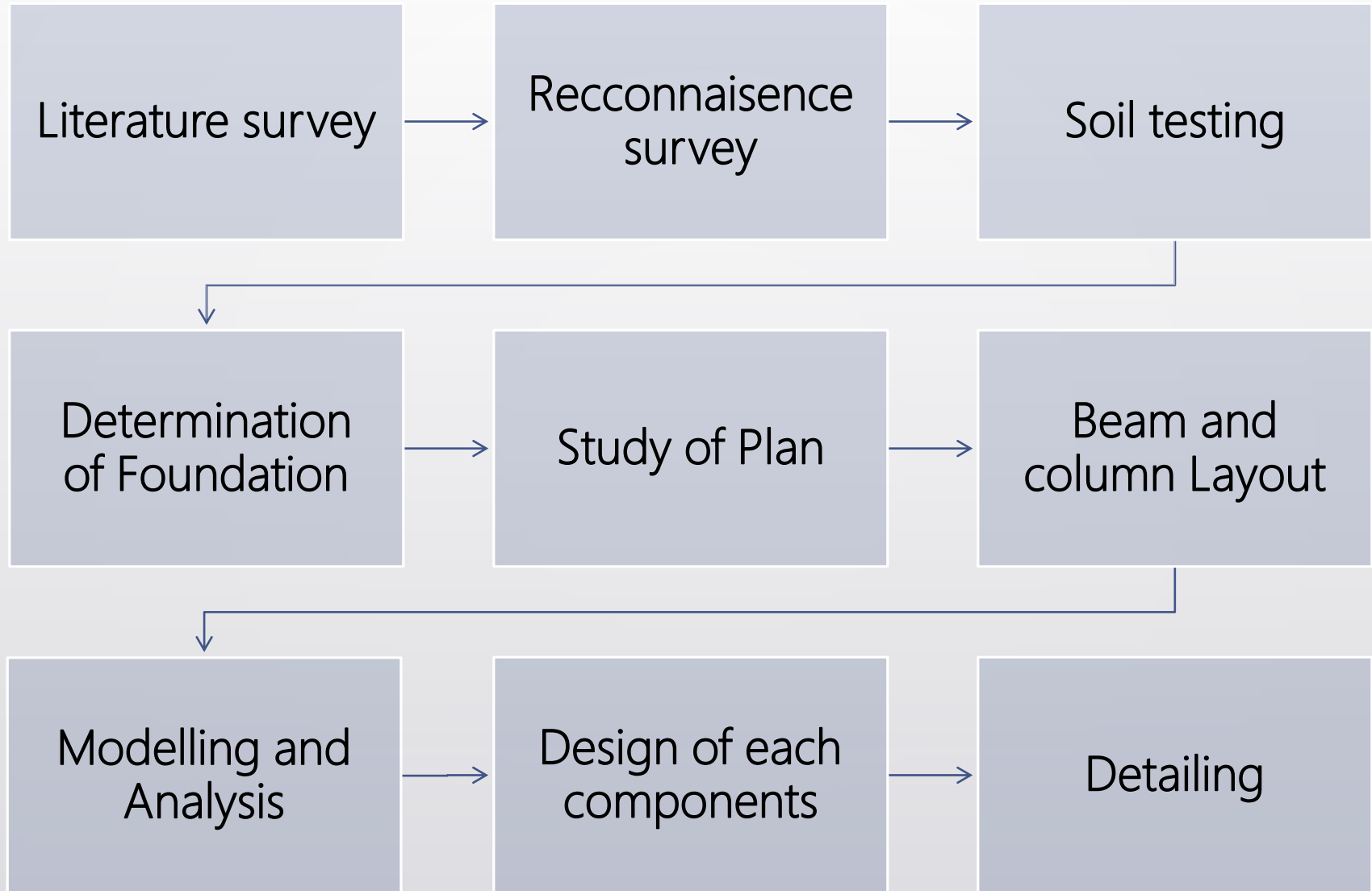
- 1.The plan configurations of structure has significant impact on the seismic response of structure in terms of displacement, story drift, story shear**
- 2. According to results Response Spectrum Analysis, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.**
- 3. Large displacement was observed in the T shape building. It indicates that building with severe irregularity shows maximum displacement and storey drift.**
- 4. According to results of RSA, it was found that mass irregular building frames experience larger base shear than similar regular building frames**

Scope And Objective



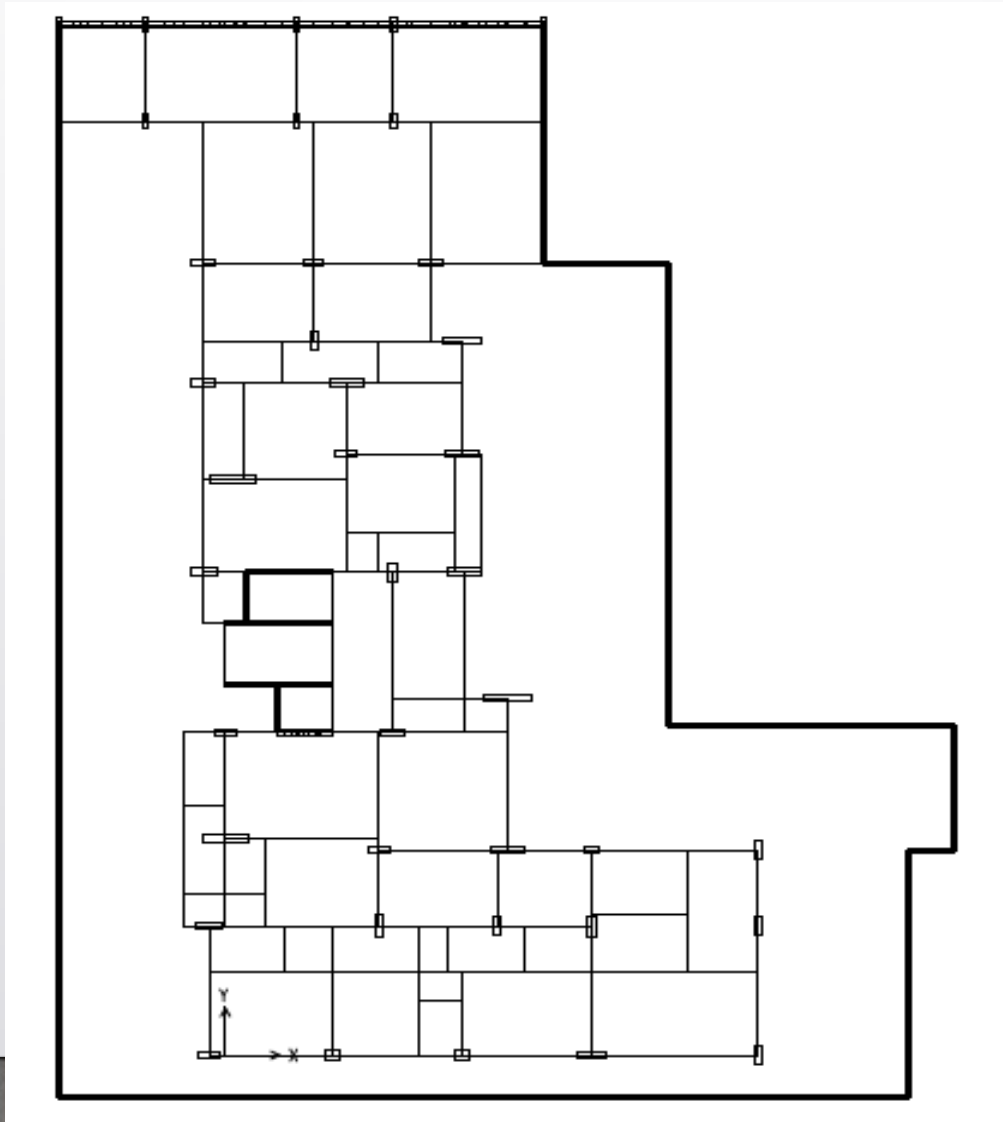
- To prepare a detailed drawing
- The main objective of the project is to analyse and design the 16 storey apartment
- This project includes analysis, design and detailing of structures like beam, column, slab, shear wall, retaining wall, stair case and water tank
- Each component is designed by considering its strength along with its aesthetics

Methodology



Analysis and Design of Multistoreyed Apartment Using Tekla

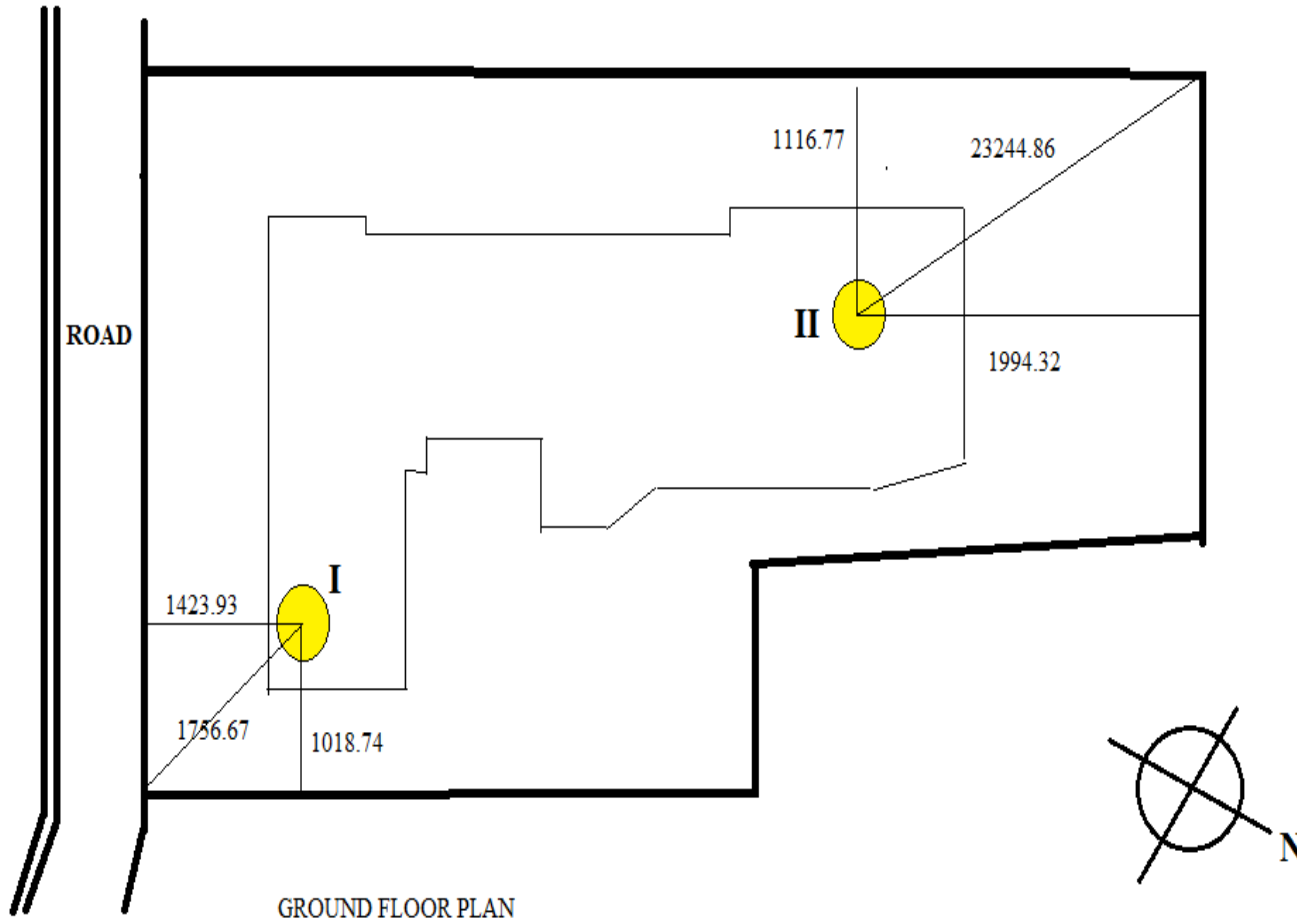
Beam-Column Layout



Analysis and Design of Multistoreyed Apartment Using Tekla **Proposed plan**



SOIL REPORT



Position Of Bore Holes

BORE CHART

Depth below G.L	Description of soil	Standard Penetration Test					Depth of collection of sample		Remarks
		Dept h (m)	15	30	45	N	D.S	UDS	
0.00	Top fill								Rock specimen collected using diamond cutter
0.50	Sand	1.50	5	6	8	14	1.50		
		3.0	5	10	15	25	3.0		
		4.50	10	16	20	36	4.50		
5.00	Laterite clay	6.0	1	0	1	1	6.0		
		7.50	1	0	1	1	7.50		
		9.0	1	1	1	2	9.0		
		12.0	1	2	2	4	12.0		
		15.0	2	3	3	6	15.0		
		18.0	4	4	5	9	18.0		
		21.0	10	14	20	34	21.0		
21.50	Disintegrated Rock	24.0	25			>50	24.0		
26.00	Rock	Rebound							



Bore Hole Details I
SITE:
 Chakkaraparambu,
 Cochin Bypass
 1.5m from ground level
TYPE OF BORING:
 Rotary Drilling

BORE CHART

Depth below G.L	Description of soil	Standard Penetration Test					Depth of collection of sample		Remarks
		Depth (m)	15	30	45	N	D.S	UDS	
0.00	Top fill								Rock specimen collected using diamond cutter
0.50	Sand	1.50	4	5	6	11	1.50		
		3.0	7	10	15	25	3.0		
		4.50	10	12	18	30	4.50		
5.00	Silty clay	6.0	1	1	1	2	6.0		
		7.50	1	1	1	2	7.50		
		9.0	1	2	1	3	9.0		
		12.0	1	2	2	4	12.0		
		15.0	2	3	4	7	15.0		
		18.0	4	5	5	10	18.0		
20.50	Laterite	21.0	10	20	25	45	21.0		
24.00	Weathered Rock	24.0	25			>50	24.0		
25.50	Rock	Rebound							



Bore Hole Details I

SITE:

Chakkaraparambu

Cochin Bypass

1.5m from ground level

TYPE OF

BORING: Rotary Drilling

RECOMMENDATION FOR FOUNDATION



- **layer of silty clay from 5m depth, shallow foundation cannot be adopted**
- **Bored cast-in-situ DMC piles, end bearing on rock, will be ideal**
- **The pile capacities shall be verified by routine pile load tests**
- **Assumptions that the bore log and test results are representative of the entire area**

Pile Capacities



The following tentative pile capacities may be adopted for the design :-

Pile Diameter (mm)	Pile Capacity (tonnes)
500	70
600	95
700	130
800	170

SOFTWARES USED:-



- **AUTOCAD 2014**

- ❑ **AutoCAD is a commercial computer aided design(CAD) and drafting software application.**
- ❑ **Developed and marketed by Autodesk, AutoCAD was first released in December 1982**
- ❑ **Since 2010,Autocad was released as a mobile and web app as well, marketed as AutoCAD 360.**

TEKLA STRUCTURAL DESIGNER 2016



- **A BIM Software from Trimble software Co-operation**
- **Analysis and design buildings efficiently**
- **Fully automated and packed with many unique features of optimized concrete and steel design**
- **Design a building structure and its components using 3D modelling, generate 2D drawings and access building information.**
- **Often used in conjunction with Autodesk Revit, where structural framing is designed in Tekla and exported to Revit using the DWG/DXF formats**

Modelling Tab

Load Tab

Analysis Tab

Analysis and Design of Multistoreyed Apartment Using Tekla

SPECIFICATION OF MATERIALS



Material Properties

- **Concrete**

Concrete of grade M_{30} is adopted in the design of columns for all floors ,slabs and beams.

- **Steel**

Steel of grade Fe_{500} is adopted for the construction

Member Properties



a) Beam

200 x 600mm

b) Column

300x600mm,300x700mm,300x800mm,300x900mm,
300x1000mm,300x1050mm,

300x1100mm,300x1200mm,300x1400mm,300x1700
mm,300x1800mm,500x500mm

c) Slab

For basement and ground floor: 150mm

For all other floors: 100mm

Member Properties



d)Stair case

The staircase is provided as an equivalent slab. The thickness of the slab used for staircase is 150 mm.

Rise = 150 mm

Tread = 300 mm

e)Shear Wall

Thickness of shear wall: 200mm

f)Retaining Wall

Thickness of retaining wall: 200mm

Beam Property

Properties

Reinforced Concre... Save... Apply...

Name	4B80
Group	CRB16-D21
Plane	St. 4 (3F) : L...
Concrete type	Normal
Characteristic	Beam
Element type	Beam
Material type	Concrete
Construction	Concrete beam
Fabrication	Reinforced
Autodesign	☒
Select bars start...	Minima
Gravity only	☐
Rotation	0.0000°
Rotation angle	0.0000°
Allow automatic ...	☒
Allow automatic ...	☒

All spans

Name	4B80
Section	250x500
Concrete type	Normal
Concrete class	M 30
Linearity	Straight
Rotation	0°
Rotation angle	0.0000°
Gamma angle	0.0000°

Releases

Alignment

Design control

Design parameters

Nominal cover b...	30mm
Nominal cover b...	30mm
Nominal cover s...	30mm
Nominal cover b...	30mm

Seismic

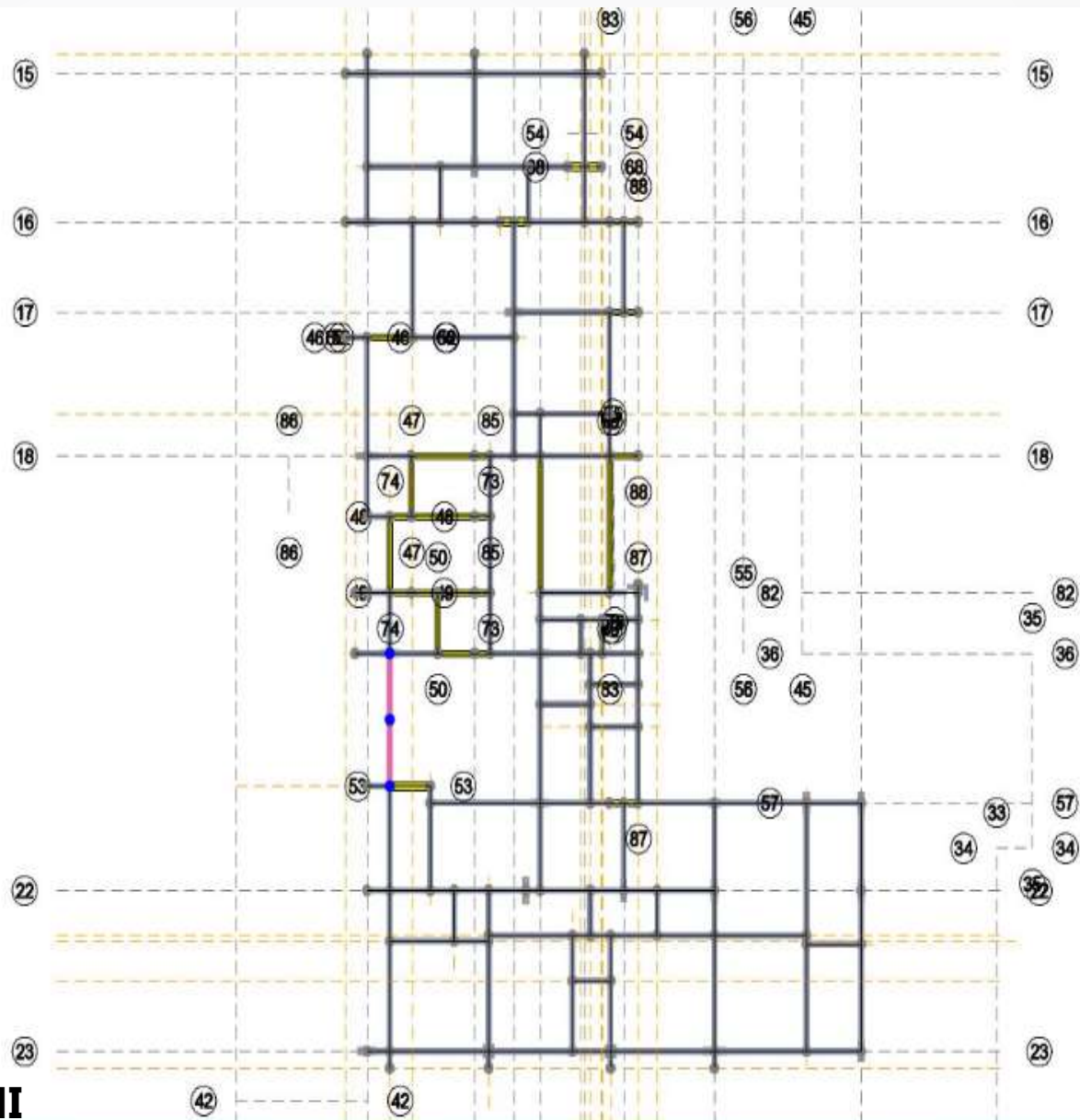
In a seismic f...	☒
SPRS direction	Direction Dir 1
SPRS type	Special mome...

LDA

Reinforcement

Rib type - longit...	Type 2
Class - longitudinal	Fe 500
Selection order ...	
Rib type - stirrups	Type 2
Class - stirrups	Fe 500

Gamma angle



Column Property

Properties

Reinforced Concre... Save... Apply...

General

Name	C6
Group	CRC50-D1
Top level	St. 18 (TER) :...
Base level	St. Base (Bas...
Plane	
Concrete type	Normal
Characteristic	Column
Element type	Beam
Material type	Concrete
Construction	Concrete colu...
Fabrication	Reinforced
Autodesign	☒
Select bars start...	Minima
Gravity only	☐
Rotation	90.0000°
Rotation angle	90.0000°
Assume extra fl...	0

All stacks

Name	
Section	300x1000
Concrete class	M 30
Linearity	Straight

Releases

☐ Alignment

☐ Design control

☐ Confinement reinforcement

☐ Slenderness

☐ Stiffness

☒ Lambda crit chec...

Nominal cover 40mm

☐ Seismic

☒ In a seismic f...

SFRS direction Direction Dir 1

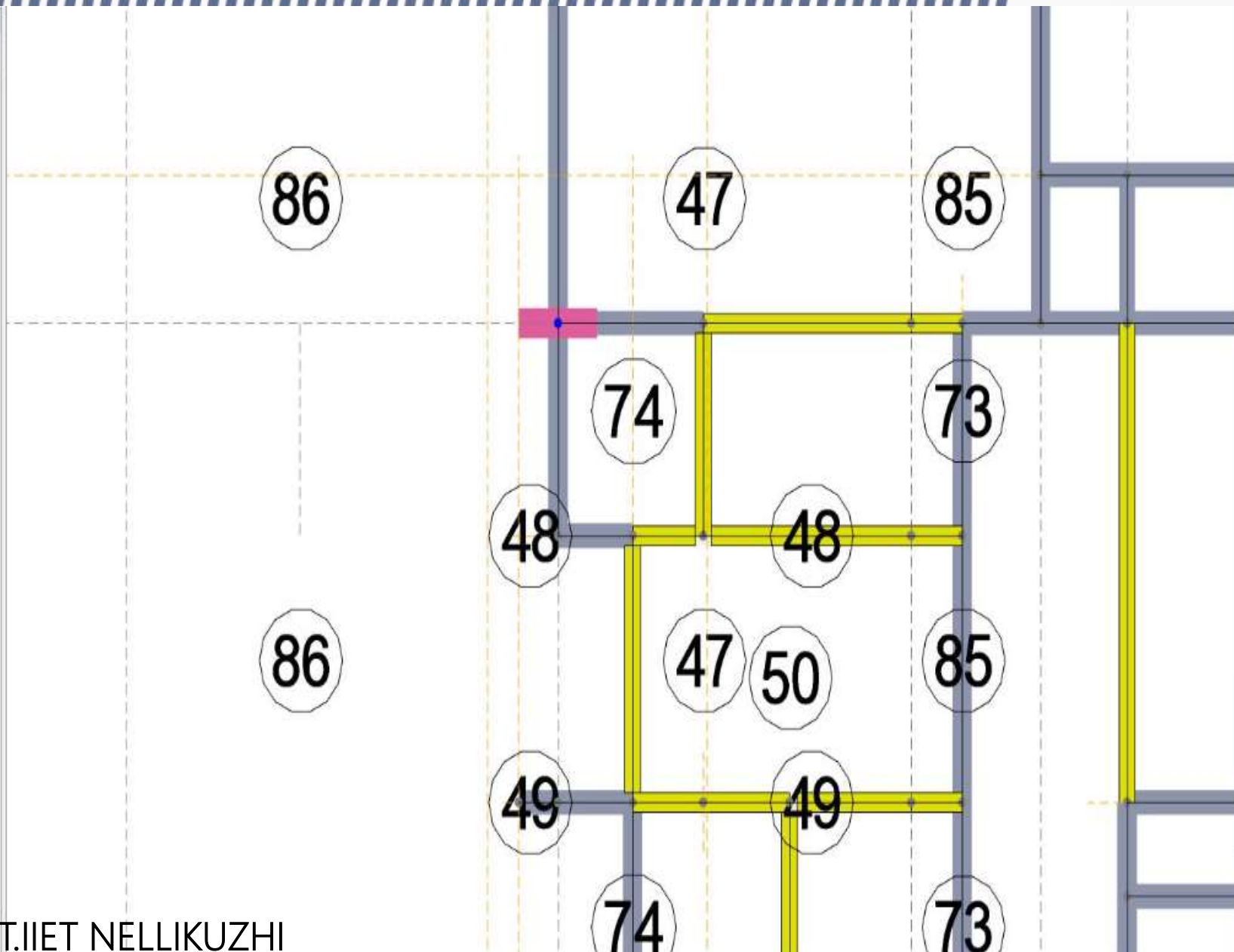
SFRS type Special mome...

UDA

Reinforcement

Rib type - vertical	Type 2
Class - vertical	Fe 500
Selection order -...	
Rib type - tie/co...	Type 2
Class - tie/conta...	Fe 500
Selection order -...	

Stack 12



LOADS ON THE BUILDING

- **Dead loads** IS : 875 (Part 1) - 1987
- **Live Loads** IS : 875 (Part 2) - 1987
- **Wind loads** IS : 875 (Part 2) - 1987
- **Earthquake Loads** IS : 1893 (Part 1) – 2002
- **Load Combinations**

Load Calculation



- **DEAD LOAD**

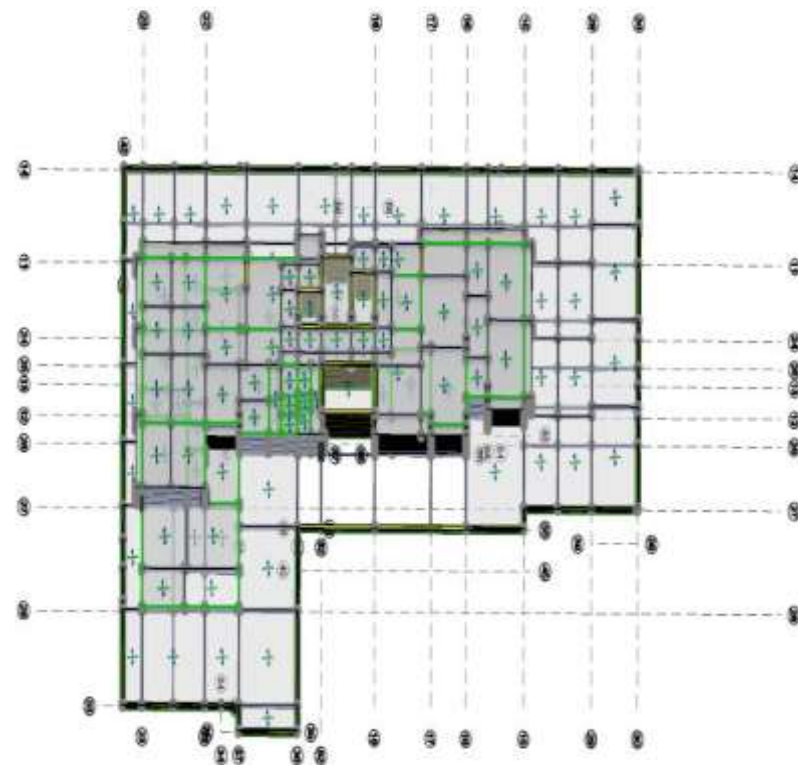
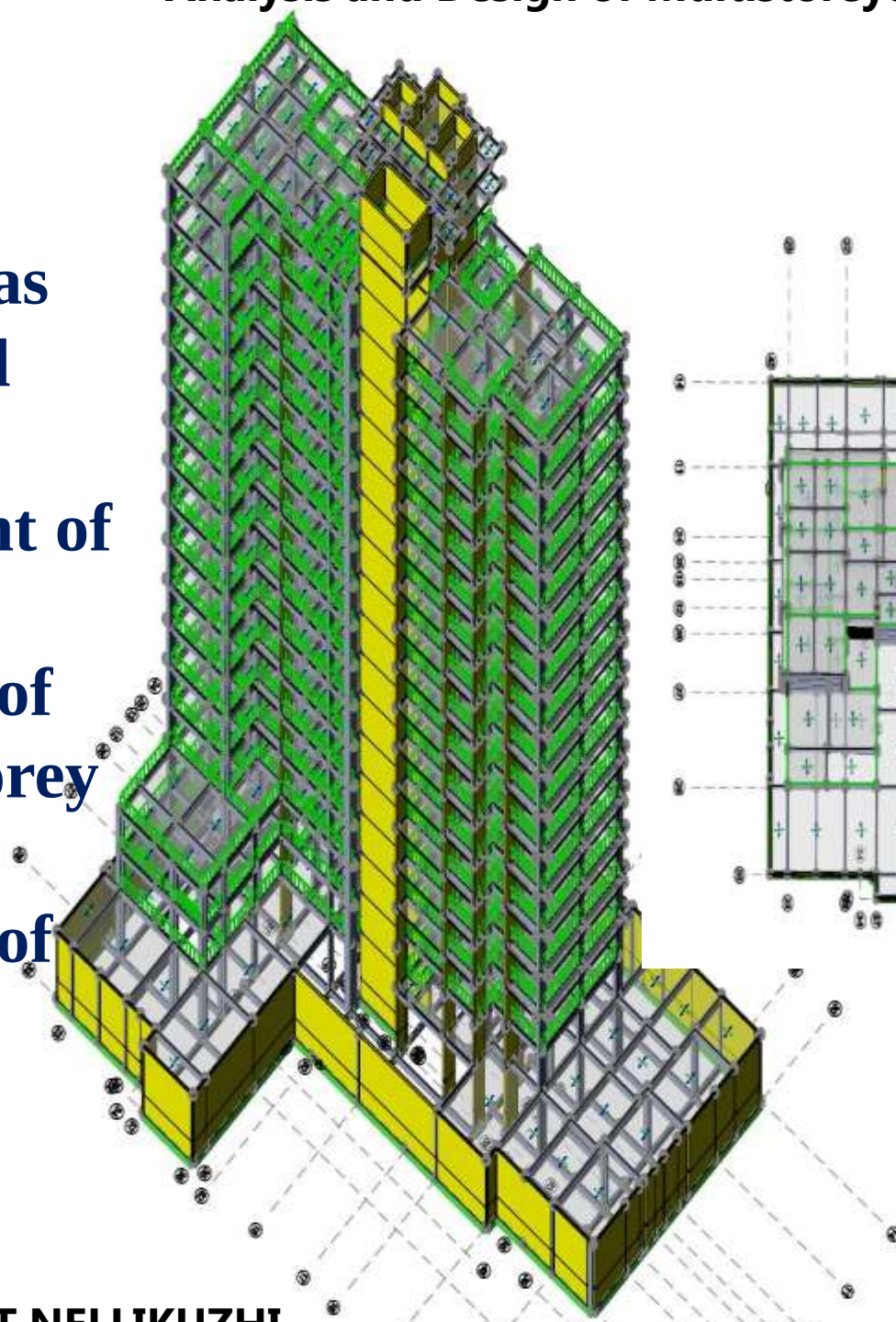
- 1) **Wall Load**
- 2) **Floor Finish**
- 3) **Service Load**
- 4) **Water tank**
- 5) **Machine room**
- 6) **Vehicle load**

DEAD LOAD

Wall Load

Assigned as
Line Load

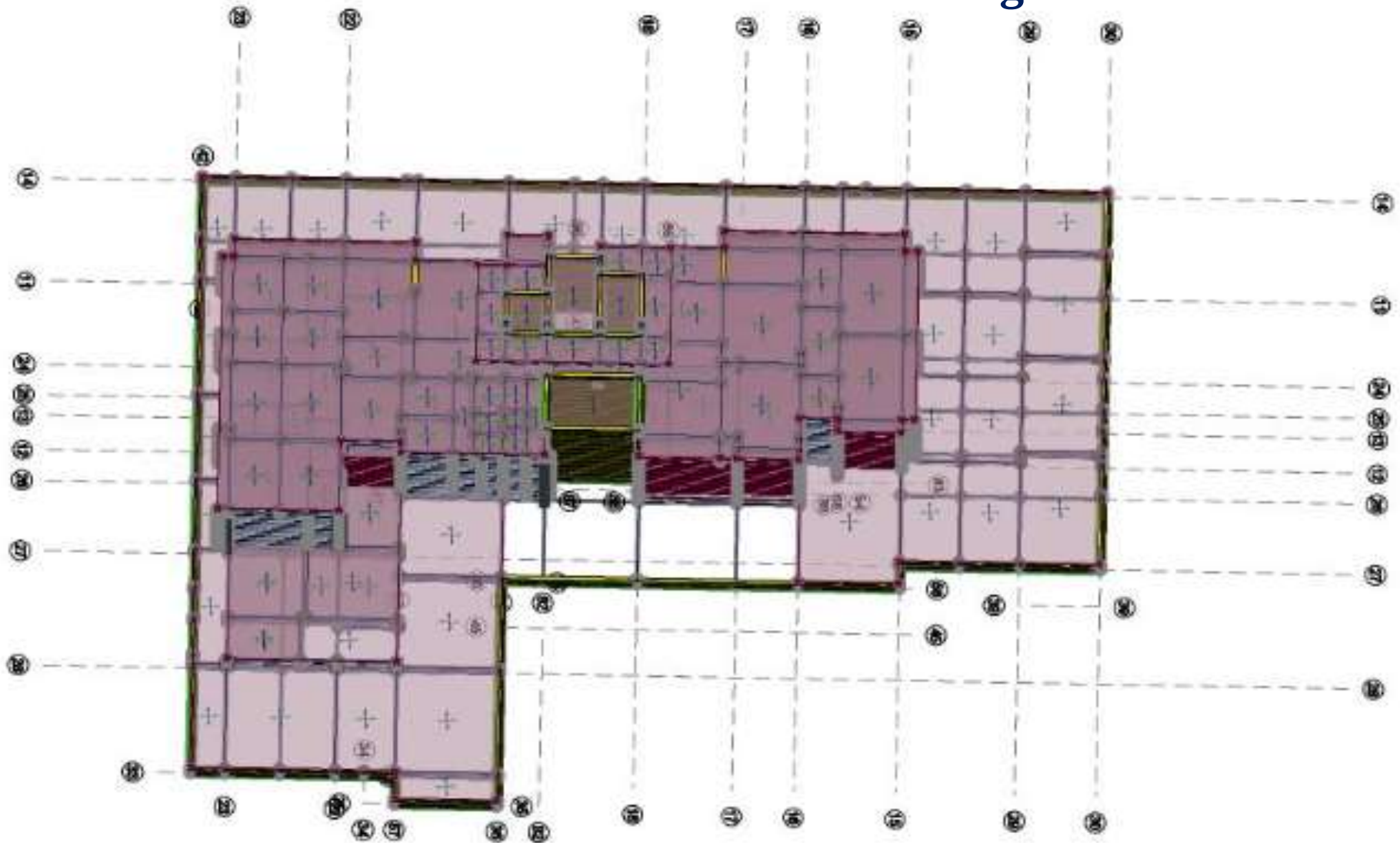
unit weight of
brick x
thickness of
wall x (storey
height-
thickness of
beam)



2)FLOOR LOADS



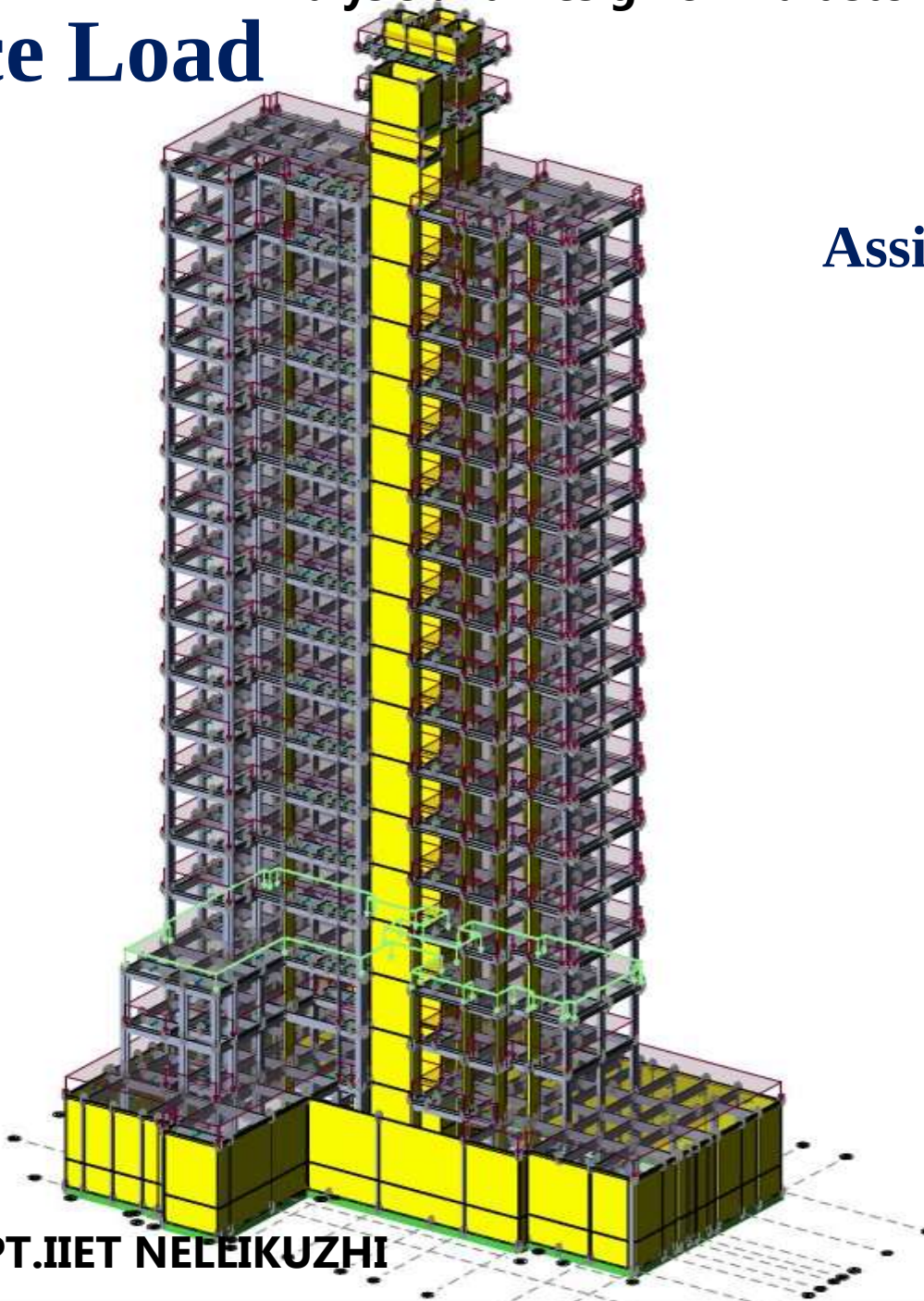
Assigned as area load





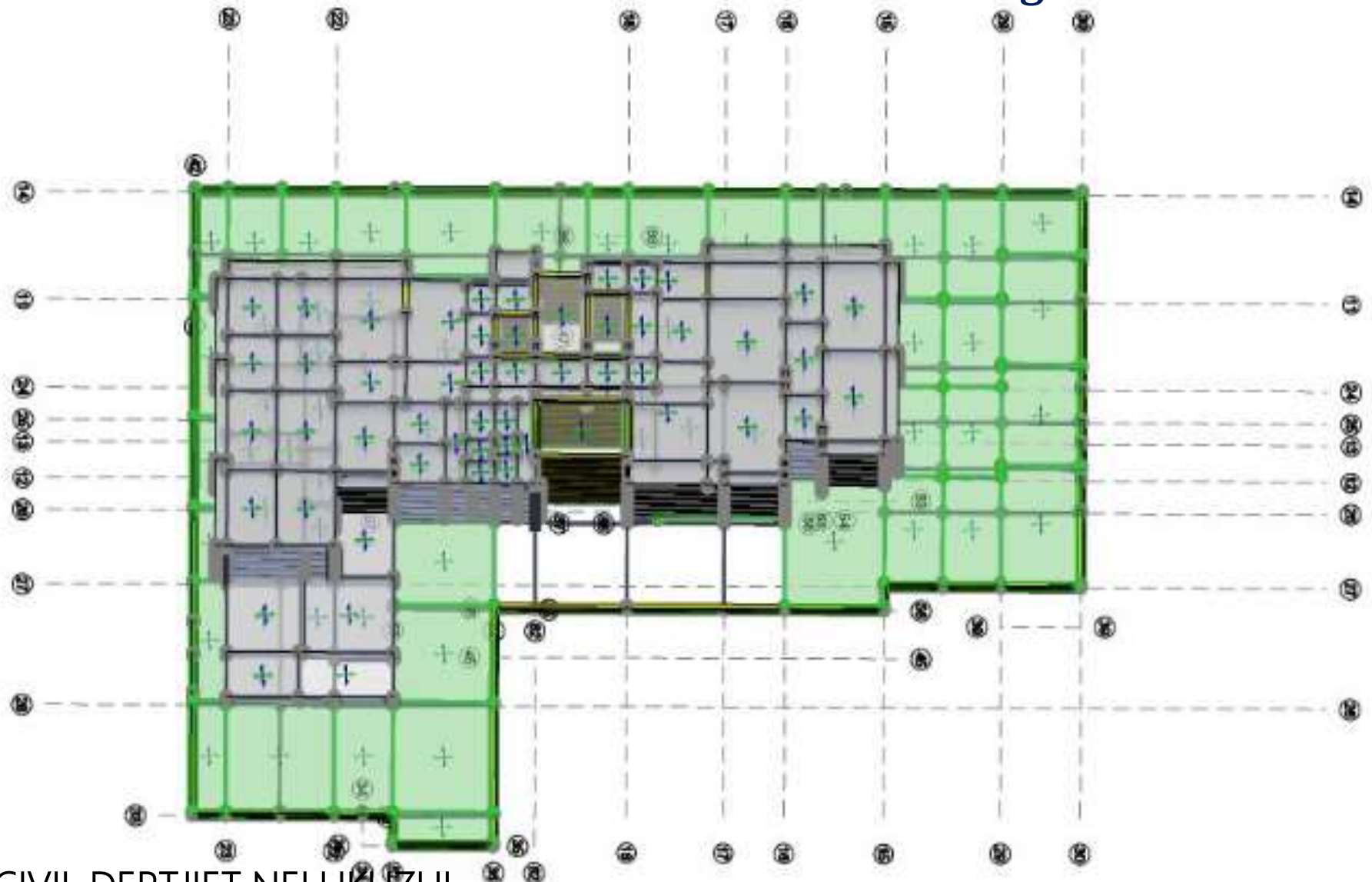
Service Load

Assigned as level load

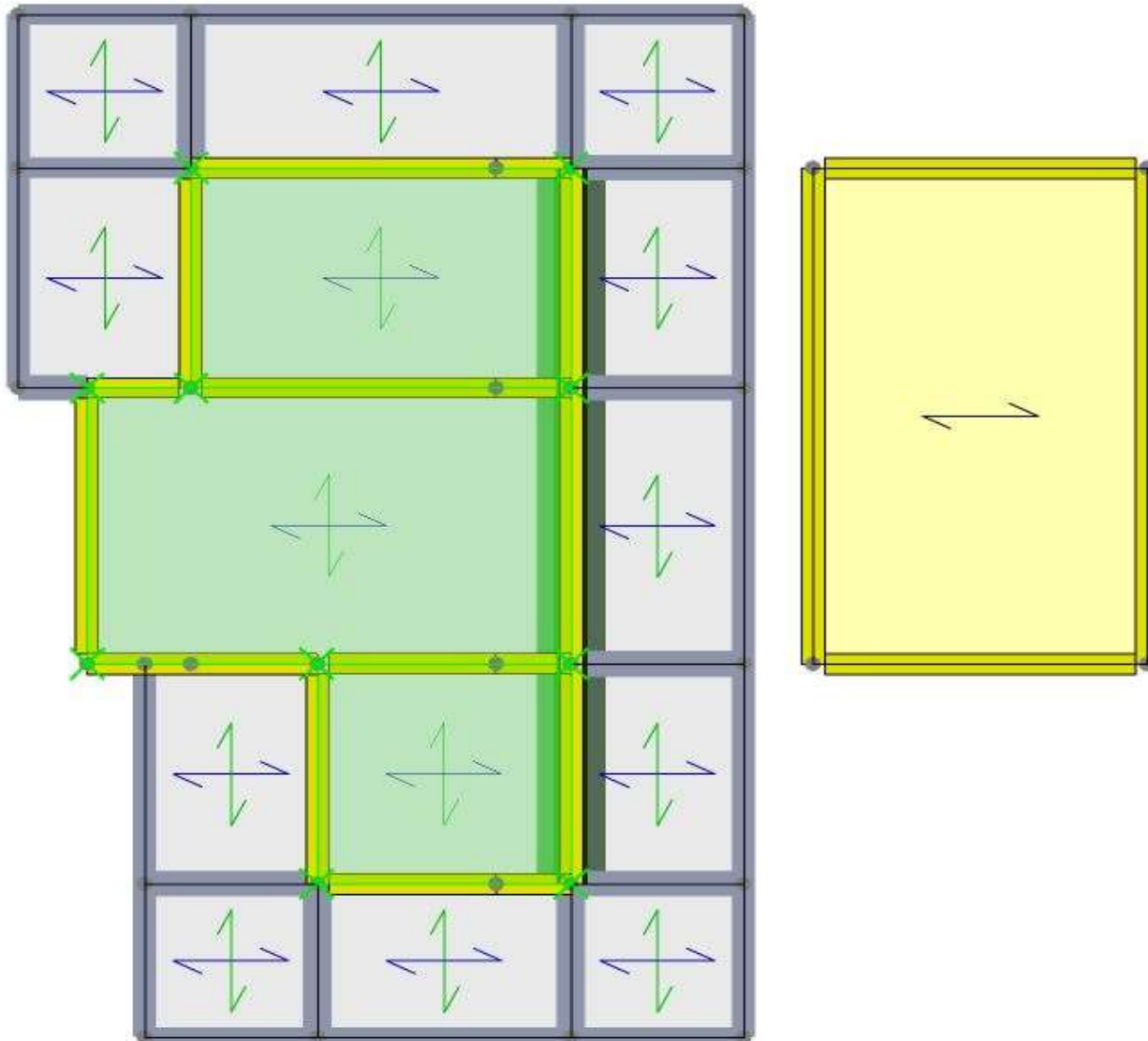


Vehicle Load

Assigned as area load



Load on Water Tanks

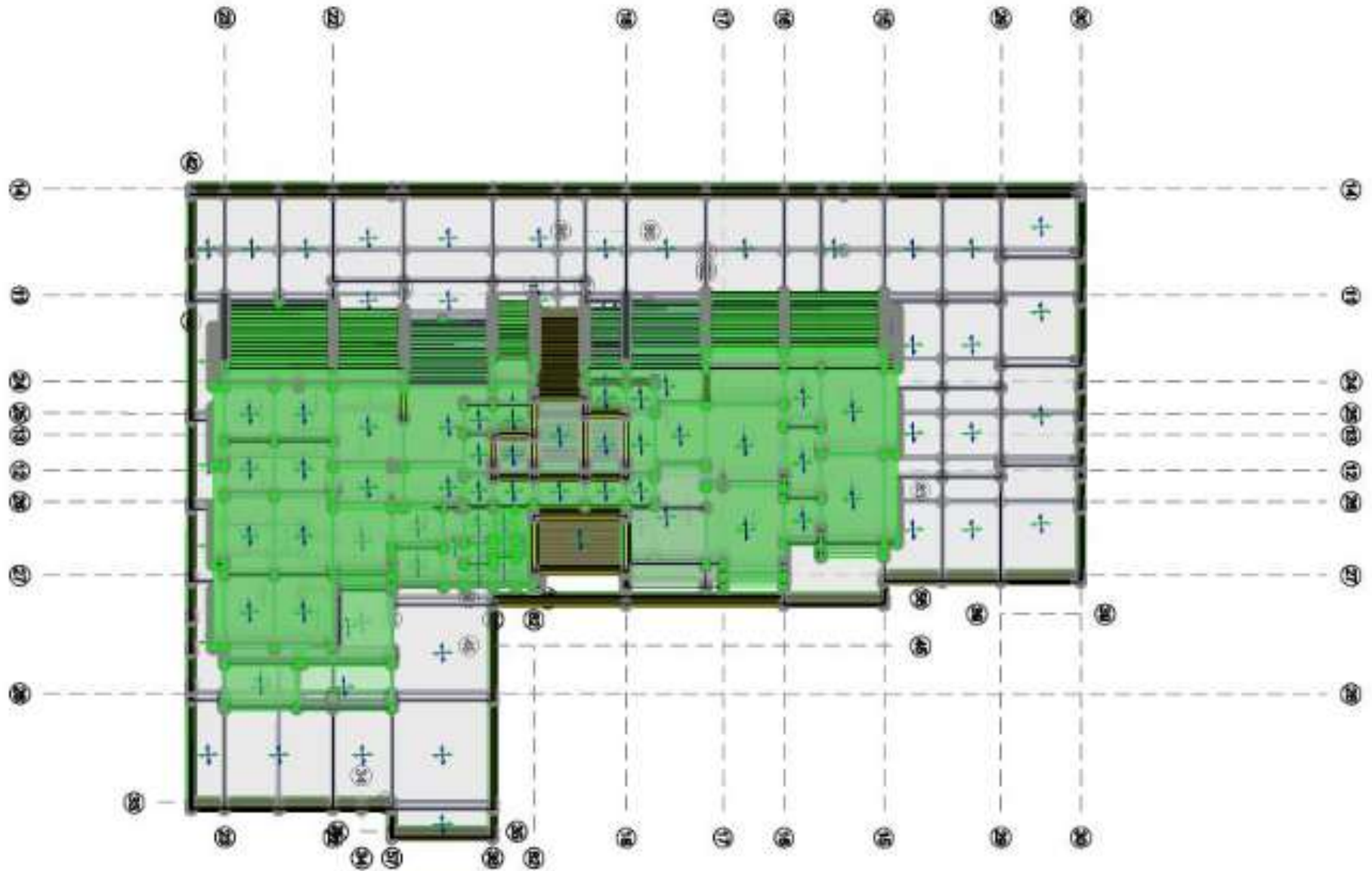




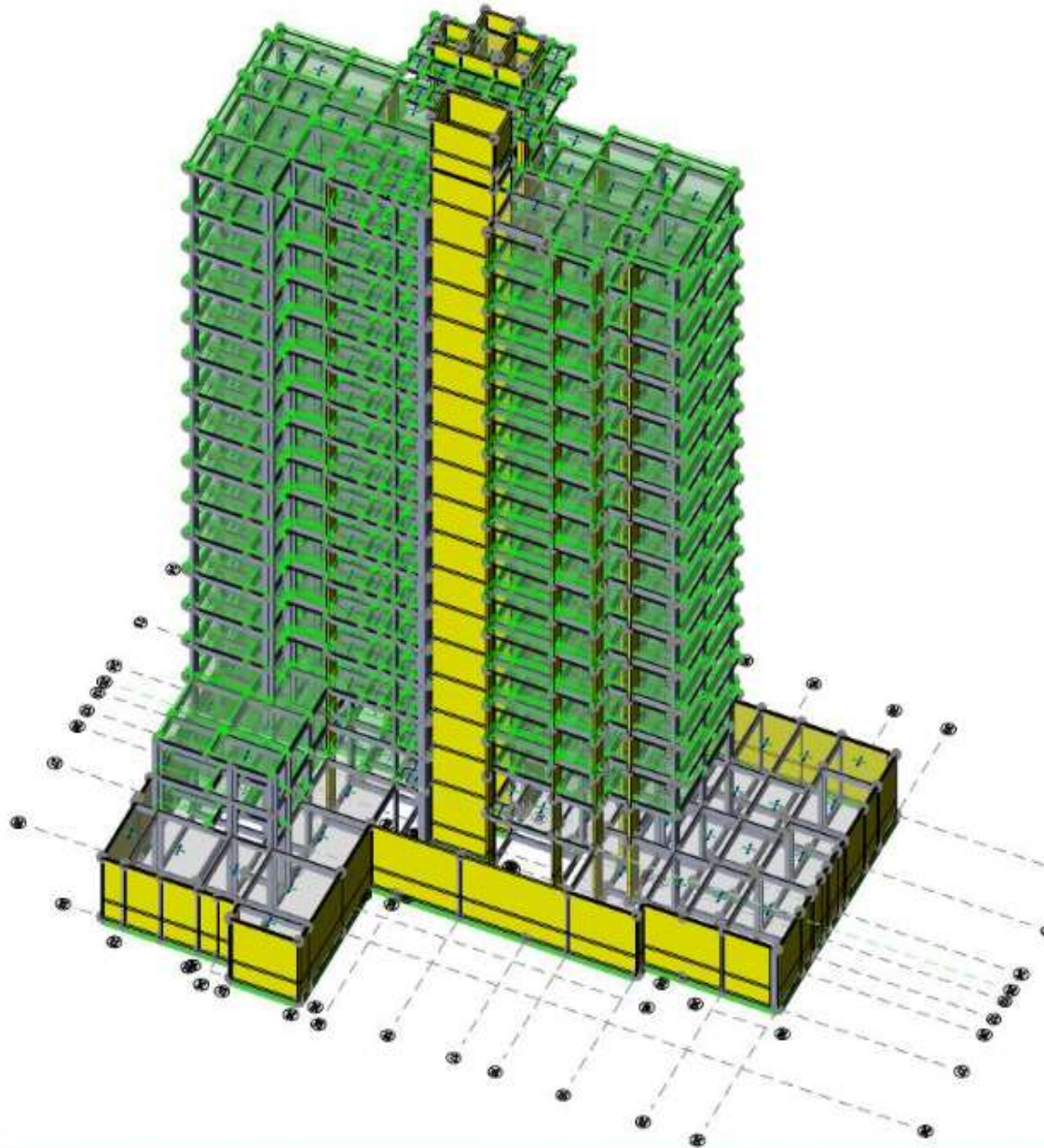
- Residential apartments are as follows:

• Living room	= 2kN/m²
• Bedroom	= 2kN/m²
• Kitchen	= 2kN/m²
• Balcony	= 3kN/m²
• Dining room	= 4 kN/m²
• Passages and corridors	= 3 kN/m²
• Toilet	= 2 kN/m²
• Terrace	= 1.5 kN/m²
• Machine room	= 5 kN/m²

Imposed Loads



Imposed Load



Wind Loads IS : 875 (Part 3) - 1987

- Design wind speed, $V_z = V_b k_1 k_2 k_3$

- Design wind pressure, $P_z = 0.6 V_z^2$

Design Wind Pressure

Basic Data

Ground Level in Model (Ignore Wind Below)	0.000	m	
Orientation	90.0000	°	
Building Height Exposed to Wind	61.900	m	☐ Override calculated
Building Width	20.700	m	☐ Override calculated
Building Length	34.650	m	☐ Override calculated
Building Type	Important buildings ▾		
Building Class	C ▾		
Basic wind speed, V_b	39.0	m/s	
Probability factor, k_1	1.060		

Cancel Previous **Next** Finish

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Wind Loads



**Wind loads are taken
as Wall panels**



Design Wind Pressure



Design Wind Pressure

Results

Direction [°]	k_1	k_2	k_3	V_{zmax} [m/s]	p_{zmax} [kN/m ²]
0.0000	1.060	1.154	1.000	47.7	1.366
90.0000	1.060	1.154	1.000	47.7	1.366
180.0000	1.060	1.154	1.000	47.7	1.366
270.0000	1.060	1.154	1.000	47.7	1.366

Add Dir.

Del Dir.

Sort Dirs.

Details...

Cancel Previous Next Finish

Earthquake Loads

IS : 1893 (Part 1) – 2002



- **The design horizontal seismic coefficient for a structure shall be determined by the following**

expression:
$$A_h = \frac{ZIS_a}{2Rg}$$

Z = Zone factor for the Maximum Considered Earthquake (MCE)

I = Importance factor, depending upon the functional use of the structures

R = Response reduction factor, depending on the perceived seismic damage performance of the structure,

Analysis and Design of Multistoreyed Apartment Using Tekla

Seismic Wizard



Base Information

Structure Details

h - Height to the highest level m

d_{Dir1} - Max. Dimension in Dir 1 m

d_{Dir2} - Max. Dimension in Dir 2 m

Ignore seismic in floor (and below)

n - Number of storeys

Zone & Site

Seismic Zone

Site Class

I - Importance Factor

Z - Zone Factor

Percentage Damping

Damping Factor

Cancel

Previous

Next

Finish

Seismic Force Resisting System

Seismic Force Resisting System Dir 1

System ii) Special RC moment-resisting frame(S

R - response reduction factor 5.000

Seismic Force Resisting System Dir 2

System ii) Special RC moment-resisting frame(S

R - response reduction factor 5.000

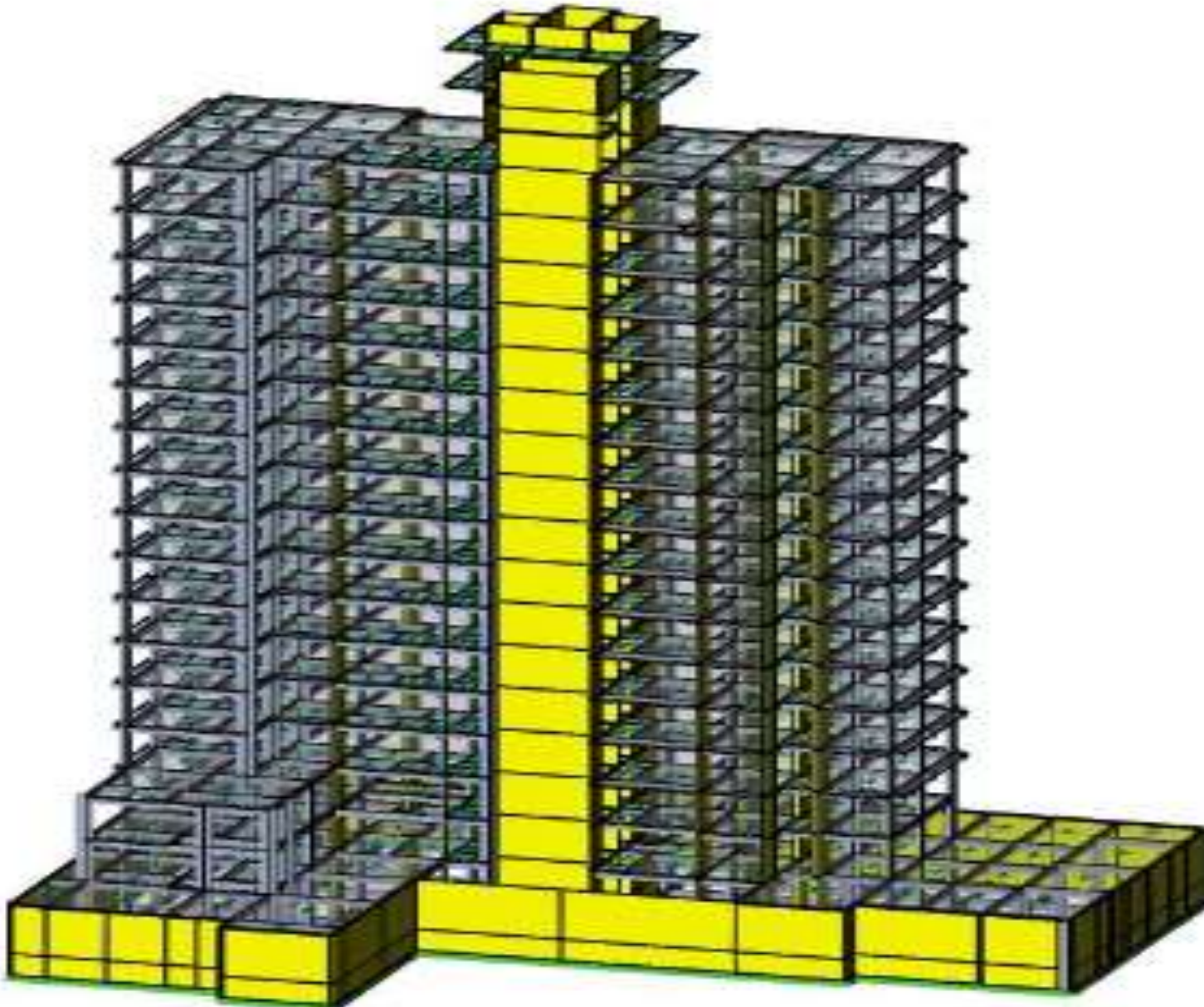
Cancel

Previous

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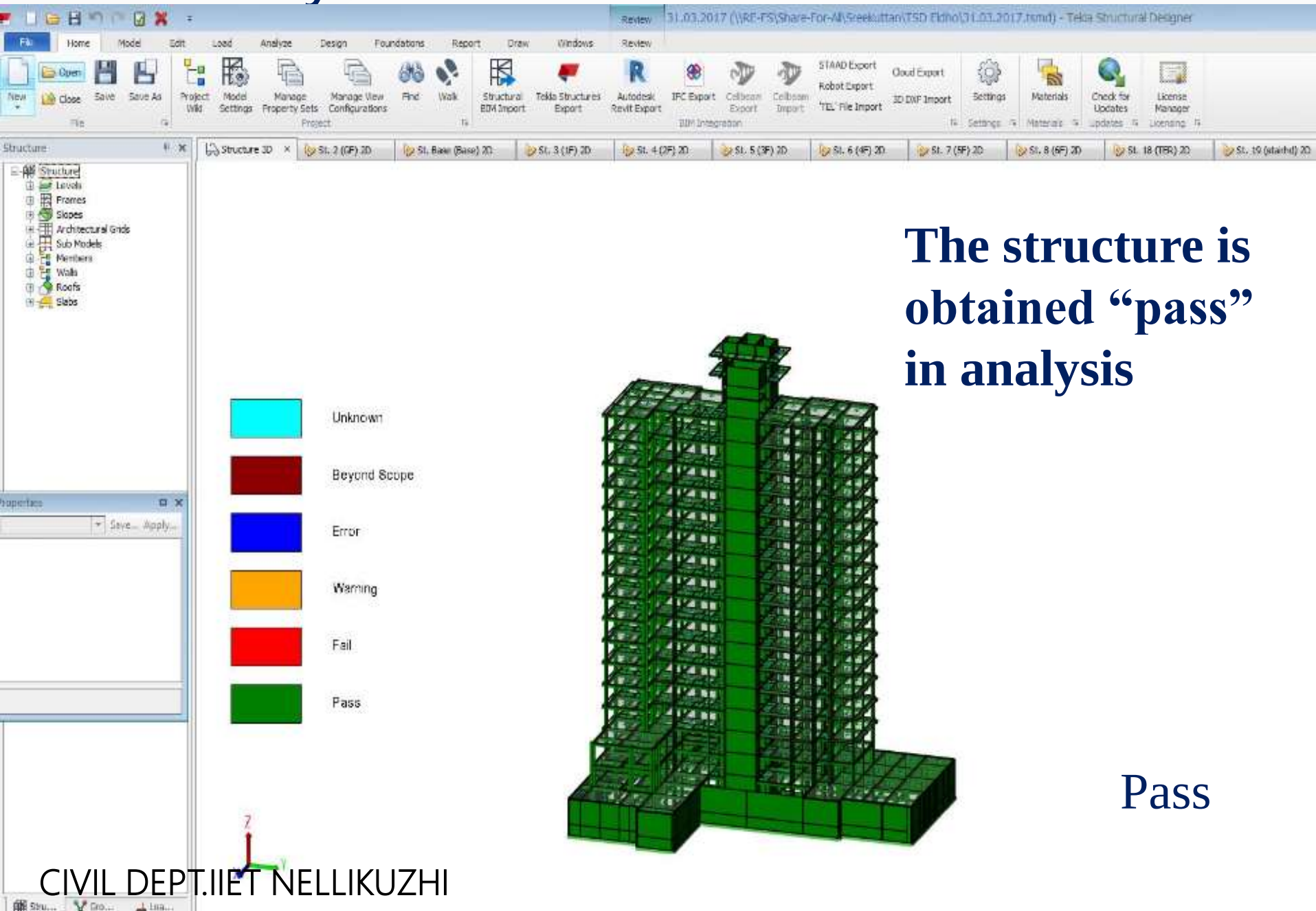
Finish

Complete View of the model



Analysis and Design of Multistoreyed Apartment Using Tekla

Analysis



Design



- Slab
- Beam
- column
- Stair Case
- Shear Wall
- Retaining Wall
- Pile
- Water tank

Material constraints used:-

M₃₀ concrete, $f_{ck} = 30 \text{ N/mm}^2$

Fe₅₀₀ steel, $f_y = 500 \text{ N/mm}^2$

Design Of Slab



a) $L_Y=4.4\text{m}, L_X=3.4\text{m}$, slab is designed as a two way slab.

b) Thickness of slab L_X
 0.8×32

c) Effective span = clear span + effective depth

d) Load Calculation

(As per IS: 875(Part 2)-1987, Table-1)

$$= (\text{Dead Load} + \text{Live load} + \text{service Load} + \text{floor finish}) \times 1.5$$

e) Ultimate design moment =

(table 26 of IS 456:2000)

$$M_{ux}(-ve) = a_x \times w_u \times L_{ex}^2$$

$$M_{ux}(+ve) = a_x \times w_u \times L_{ex}^2$$

$$(M_{uy}(-ve)) = a_y \times w_u \times L_{ex}^2$$

$$M_{uy}(+ve) = a_y \times w_u \times L_{ex}^2$$

Design Of Slab



f) Check For Dept $(M_u)_{lim} = 0.133 \times f_{ck} \times b \times d^2$

$$d_{required} = \sqrt{\frac{(M_u)_{lim}}{0.133 \times f_{ck} \times b}}$$

g) Reinforcements along short and long span directions

$$M_u = 0.87 \times f_y \times A_{st} \times d \left(1 - \frac{A_{st} \times f_y}{b \times d \times f_{ck}} \right)$$

$$\text{Spacing, } S = \frac{\text{Area of one bar}}{\text{total area}} \times 1000$$

Analysis and Design of Multistoreyed Apartment Using Tekla

Design Of Slab



- Reinforcement details in Slab

Location	(required)	Spacing of 10mm ϕ bars	(provided)
1)short span			
-ve BM(top of supports)	109 mm ²	300 mm	262 mm ²
+ve BM(centre of span)	90 mm ²	300 mm	262mm ²
2)long span			
-ve BM(top of supports)	83 mm ²	300 mm	262 mm ²
+ve BM(centre of span)	70 mm ²	300 mm	262 mm ²

Design Of Slab



- **h) Check for spacing**
- **i) Check for area of steel**
- **j) Check for deflection**
- **k) Check for shear**
- **l) Check for cracking**

Design of Beam



- $L = 500 \text{ mm}$, $b = 250 \text{ mm}$
- **Effective Span** As per IS 456:2000, clause 22. 2
- **Design Values from Tekla**

Support moment = 58.04kNm

Mid span moment = 37.26kNm

Shear force = 67.23kN

Design of Beam



- **Limiting Moment of Resistance** = $(M_u)_{lim} = 0.133 \times f_{ck} \times b \times d^2$
- **Design for maximum mid span moment,**

$$M_u < M_{u,limit}$$

the beam is to be designed as a singly reinforced beam

Design of Beam



- Calculation of area of steel at mid span $\frac{M_u}{bd^2}$

Provide 2 no: of 20 mm diameter bars at mid span ($=628 \text{ mm}^2$)

- Check for minimum & maximum steel

As per IS: 456-2000, clause 26.5.1.1. (a) and 26.5.1.1.(b)

$$A_{st \min} = \frac{0.85bd}{f_y}$$

$$A_{st \max} = 0.04bD$$



- Check for shear

$$\tau_v > \tau_c < \tau_{c,max}$$

- Shear reinforcement is to be provided.
- Strength of shear reinforcement =

$$V_{us} = (V_u - \tau_c bd)$$

$$S_v = \frac{0.87 f_y A_{sv} d}{V_{us}}$$

- Spacing of stirrups =
- Provide 8 mm diameter 2 legged stirrups at 300mm spacing

DESIGN OF COLUMN



- **D** = 1000 mm, **b** = 300 mm
- **Support condition**= both ends fixed
- **Effective Length**= $L_{\text{eff}} = 0.65 \times l$
- **Type of column** = $\frac{L_e}{D} < 12$ = Short Column
- **Results from Tekla**
- **Factored axial load**, $P_u = 7234.17 \text{ kN}$
- **Factored moment in x-direction**, $M_x = 702.49 \text{ kNm}$
- **Factored moment in y-direction**, $M_y = 42.369 \text{ kNm}$

DESIGN OF COLUMN

- Calculation of eccentricity =

$$e_x = \frac{l}{500} + \frac{b}{30}$$

$$e_y = \frac{l}{500} + \frac{D}{30}$$

- Moments due to minimum eccentricity = $M_{ux} = P_u \times e_x$

- Longitudinal reinforcement

(0.8% - 6% is the range of minimum steel area of column as per IS 456: 2000)

$$\frac{P_u}{b \times d \times f_{ck}} \text{ and } \frac{M_{ux1}}{f_{ck} \times b d^2} \text{ (From chart 50 of SP 16)}$$

Provide 20 number of 30 diameter bars.

DESIGN OF COLUMN



- **Check for safety under biaxial loading**

Provide 20 numbers of 36 mm ϕ bars distributed equally on four sides.

- **Lateral ties** *IS 456:2000, clause 26.5.3.2(c), page 49*

10mm lateral ties

- **Pitch** *IS 456:2000, clause 26.5.3.2(c),*

provide 10mm diameter bars @ 300 mm c/c

- **Special confining reinforcement** *IS 13920:1993 clause 7.4.1*

So provide 10 mm ϕ bars at 75 mm c/c up to a length of 1000 mm from face of the joint towards mid span and 10 mm ϕ bars at 200 mm c/c at all other places.

DESIGN OF STAIRCASE



- **Riser** = 150 mm, **Tread** = 300 mm
- **Thickness of waist slab**:- $\frac{l}{32}$
- **Load on waist slab**:-
- **Dead Load**=
$$\frac{\text{Thickness of waist slab} \times 30 \times \sqrt{R^2 + T^2}}{T}$$
- **self weight**= $\frac{1}{2} \times \text{rise}$
- **Total Ultimate Load**
 = (self weight+ Live Load +Floor finish +Service Load)1.5

DESIGN OF STAIRCASE



- **Ultimate Design Moment =**

$$M_U = \frac{w_u \times L_E^2}{8}$$

- **Check for depth of waist slab =**

$$d_{\text{required}} = \sqrt{\frac{M_u}{0.133 \times f_{ck} \times b}}$$

$$d_{\text{required}} < d_{\text{provided}}$$

the effective depth selected is sufficient to resist the design ultimate moments.

- **Calculation of Reinforcements =**

$$\frac{M_u}{bd^2}$$

$$A_{st} = \frac{P_t bd}{100}$$

$$\text{Spacing, } S = \frac{1000 \times A_{\phi}}{A_{st}}$$

- 12mm Ø bars at 110mm c/c.

DESIGN OF STAIRCASE



- **Distribution steel** = $0.12\%bt$

8 mm diameter bars at 270mm c/c

- **Check for shear**

$$\tau_v = \frac{V_u}{bd}$$

$$\tau_v < \tau_c < \tau_{cmax}$$

- **So shear reinforcement is not required.**

. DESIGN OF SHEAR WALL



Horizontal length $l_w = 2100$ mm.

Thickness of the wall, $t_w = 200$ mm

Effective depth of wall, $d_w = 0.8 l_w$

• Results from Tekla

Factored axial load, $P_u = 4344$ kN

Factored shear force, $V_u = 374$ kN

Factored moment, $M_u = 1092$ kNm

Check for Boundary Elements

$f_c < 0.2 f_{ck}$

provision of boundary elements is required as per IS 13920 : 1993, Cl. 9.4.1a
length of 500 mm on both sides of the wall to act as boundary elements

DESIGN OF SHEAR WALL



- Checking whether two layers of steel are required
- As per IS 13920:1993, clause 9.1.5, if the factored shear stress in the wall exceeds 0.25 or if the wall thickness exceeds 200 mm, reinforcement shall be provided in two curtains
- Provide two layers of steel here
- **Check For Maximum Shear Stress**
- As per IS 13920:1993, clause 9.2.3 The nominal shear stress in the wall, v , shall not exceed τ_c max, as per Table 20 of IS 456 : 2000

$$\tau_v > \tau_c$$

- shear reinforcement is needed.

DESIGN OF SHEAR WALL

- Calculation Of Reinforcement

$$A_{st} = 0.0025 \times 200 \times 1000$$

$$\text{spacing}_{\text{req}} = \frac{\text{Area of one bar}}{\text{total area}} \times 1000$$

- 10mm ϕ bars at 250mm c/c in two layers
- Calculation Of Moment Of Resistance Of Rectangular Shear Wall Section

$$\phi = \frac{0.87 \times f_y \times \rho}{f_{ck}}$$

$$\lambda = \frac{P_u}{f_{ck} \times t_w \times l_w}$$

$$\beta = \frac{0.87 f_y}{0.0035 E_s}$$

- the wall is safe in bending.
- Section is safe in flexure

DESIGN OF RC BASEMENT WALL



- **Height of retaining wall, h** = 3.6 m
- **Thickness of retaining wall** = 200 mm
- **Angle of repose, ϕ** = 30°
- **Active earth pressure** = $k_a = \frac{1 - \sin \phi}{1 + \sin \phi} = \frac{1 - \sin 30}{1 + \sin 30} = 0.33$
- **Unit weight of soil, γ_s** = 18 kN/m^3
- **Unit weight of water, γ_w** = 10 kN/m^3
- **Active earth pressure due to soil** = $k_a \gamma_s h$
- **Active earth pressure due to water table** = $w h$

DESIGN OF RC BASEMENT WALL



Height ,m	Soil pressure ,kN/m ²
0	0
0.9	4.8
1.8	11.1
2.7	20.1
3.6	29.1

Earth Pressure Calculation

DESIGN OF RC BASEMENT WALL



- Design of Bars in horizontal direction
- area of reinforcement is calculated using the relation:

$$M_u = 0.87 \times f_y \times A_{st} \times d \left(1 - \frac{A_{st} \times f_y}{b \times d \times f_{ck}} \right)$$

$$\text{Spacing} = \frac{\text{Area of one bar}}{\text{total area}} \times 1000$$

- provide 16 mm ϕ bars at a spacing of 100 mm c/c.
- Design of bars in vertical direction
- provide 16 mm ϕ bars at a spacing of 90 mm c/c.

DESIGN OF RC BASEMENT WALL



- Check for area of steel
- $(A_{st})_{min} = 0.12\% \text{ of cross sectional area}$
- Hence Safe
- Check for spacing
- Maximum spacing is the lesser of $3d$ or 300 mm

Spacing max = 300 mm

Spacing prov < spacing max

- provide $16 \text{ mm } \phi$ bars at a spacing of 100 mm c/c in horizontal direction and
- $16 \text{ mm } \phi$ bars at a spacing of 90 mm c/c in vertical direction.

Design Of Pile



Sl No.	Pile diameter	Pile capacity	Factored capacity
1	700 mm	1700 kN	2550 kN

- Design of 700 mm Diameter Pile

As per IS 2911 (Part-1 / Section-2) : 1979

Moment due to horizontal force, $M_u = 11.63 \text{ kNm}$

Axial load on pile, $P_u = 2451 \text{ kN}$

$$\frac{P_u}{f_{ck} D^2}$$

$$\frac{M_u}{f_{ck} D^3}$$

Design Of Pile



- $P_{\min} = 0.8\%$ of total c/s area
- provide 13 numbers of 20 mm diameter bars as longitudinal reinforcement. Provide 10 mm diameter circular links at 150 mm c/ spacing.
- provided up to fixity depth $10D = 7 \text{ m}$

Design Of Pile



- For depth after 7 m, provide minimum longitudinal reinforcement as per IS 2911 (Part-1 / Section-2) : 1979.
- Minimum area of longitudinal steel = 0.4% of total c/s area = 2010 mm²
- Hence provide 7 numbers of 20 mm diameter bars as longitudinal reinforcement.
- Provide 8 mm diameter circular links at 200 mm c/c spacing.

DESIGN OF PILE CAP



- Diameter of pile, $d = 700 \text{ mm}$
- a pile cap is designed for a group of 2 piles of dia 700 mm here
- As per IS 2911, spacing between 2 piles $= 2 d$
- Depth of pile cap = Development length of column bar + cover (SP 16 ,Table 65)
- Breadth of pile cap $= \text{Diameter of pile} + 2 \times 150 \text{ mm}$ overhang

DESIGN OF PILE CAP



- Results From Tekla
- Factored axial load on pile = 1752 kN
- Bending moment in pile cap at the face of the column =
 $1751 \times 0.275 = 482 \text{ kNm}$
- Main Reinforcement

$$\frac{M_u}{bd^2}$$

(SP 16 Table 4), take pt value

$$A_{st} = \left(P_t \frac{b \times d}{100} \right)$$

- , provide 10 nos of 16 mm Ø bars

DESIGN OF PILE CAP



- Shear Reinforcement
- Distance from face of the column to the center of the pile = 0.275 m < depth of pile / 2

$$S_v = \frac{0.87 \times f_y \times A_{sv}}{0.4 \times b}$$

- Provide 10 mm diameter 4 legged stirrups at 250 mm c/c.

DESIGN OF PILE CAP



Side Face Reinforcement As Per IS 456 : 2000 26.5.1.3

- since the depth of pile cap is greater than 750 mm, side reinforcement needs to be provided
- Side face reinforcement = 0.1 % of web area
- Hence provide 12 mm $\varnothing$ bars at 200 mm c/c on each face
- safe

DESIGN OF WATERTANK



As per IS 456:2000, Table 23,

Permissible stress in concrete, $= 10 \text{ N/mm}^2$

Permissible stress in steel, $= 275 \text{ N/mm}^2$

As per SP: 16 -1980, clause 6.1, page 189,

$$m = \frac{280}{3 \times \sigma_{cbc}}$$

$$j = 1 - \frac{k}{3}$$

$$k = \frac{m \sigma_{cbc}}{m \sigma_{cbc} + \sigma_{st}}$$

Longer side of tank wall (length), $l = 4.85 \text{ m}$

Shorter side of tank wall (breadth), $b = 2.9 \text{ m}$

Height of tank wall, $a = 2.6 \text{ m}$

DESIGN OF WATERTANK

Location	(required)	Reinforcement (Spacing of 8mm diameter bars)
Short span	178.42 mm ²	250 mm
Long span	114.68 mm ²	400 mm

CONCLUSION



- **In the project the analysis of a 16 storeyed apartment proposed at Chakkaraparambu, Kochi bypass.**
- **The dead load & live loads are applied and the design for beams, columns, slab, pile, water tank, stair case and retaining wall, shear wall are worked out.**
- **The planning of the structure was done in the software AutoCAD.**
- **The analysis was carried out in Tekla Structural Designer 2016 followed by modelling of its B+G+15 floors**

REFERENCE



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